Public safety broadband network use-case—wildland-urban interface fire

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Abstract

Public safety broadband wireless communications is an emerging capability that will provide public safety users with broadband wireless connectivity in support of feature rich applications that will greatly enhance their communications and information sharing capabilities. There are many public safety broadband initiatives worldwide that are currently underway. In Canada, the public safety broadband initiative is known as the public safety broadband network (PSBN), which is essentially a cellular network much like commercial cellular networks, but built for public safety users.

Traditionally, first responders and public safety users use land mobile radio (LMR) with push-to-talk voice and an ability to send and receive data but only in a very limited manner. In some cases, users augment their radio communications with commercial cellular service, providing them access to broadband data services. This report compares the effectiveness of LMR complemented by commercial cellular service with a PSBN service in the context of a theoretical wildland-urban interface fire use-case.

Significance to defence and security

This Scientific Report will inform the public safety and defence communities on the impact the PSBN could have while anticipating, responding to and recovering from a major emergency such as a wildland-urban interface fire. The report compares the use of land mobile radio (LMR) and commercial cellular service to using PSBN while addressing the wildfire at various stage of advancement. Consideration of the findings as described in this document will significantly contribute to the successful implementation of the PSBN in Canada.

The Director Generals of Defence Research and Development Canada – Centre for Security Science (DRDC CSS), Public Safety Canada (PS) and Innovation, Science and Economic Development (ISED) all have a high level of interest in the contents and findings of this Scientific Report, as does the PSBN Federal/Province/Territorial Interoperability Working Group (F/P/T IWG) which has been expanded to include municipalities and the tri-services.

Résumé

Les communications sans fil à large bande de sécurité publique constituent une capacité émergeante qui fournira aux utilisateurs de sécurité publique une connectivité sans fil à large bande pour appuyer des applications riches en fonctionnalités qui amélioreront grandement leurs capacités de communications et de partage de l'information. De nombreuses initiatives de sécurité publique dans le monde entier sont actuellement en cours. Au Canada, l'initiative de sécurité publique à large bande est connue sous le terme de Réseau à large bande de sécurité publique (RLBSP) qui est essentiellement un réseau cellulaire semblable à des réseaux cellulaires commerciaux, mais créé pour des utilisateurs de sécurité publique.

Traditionnellement, les premiers intervenants et utilisateurs de sécurité publique utilisent la radio mobile terrestre (RMT) avec messagerie vocale instantanée à bouton d'émission (PTT) et capacité à transmettre et recevoir des données, mais seulement de manière très limitée. Dans certains cas, les utilisateurs accroissent leurs communications radio avec un service cellulaire commercial, leur permettant d'accéder aux services de transmission de données à large bande. Ce rapport compare l'efficacité de la RMT complétée par le service cellulaire commercial avec un service RLBSP dans le contexte d'un cas théorique d'application pour les feux dans les zones périurbaines de végétation.

Importance pour la défense et la sécurité

Ce rapport scientifique informera les communautés de sécurité publique et de défense de l'impact possible du RLBSP en anticipant une urgence majeure, en y répondant et en y remédiant, comme dans le cas d'un feu dans les zones périurbaines de végétation. Ce rapport compare l'utilisation de radio mobile terrestre (RMT) et de service cellulaire commercial à l'utilisation de RLBSP, en traitant le feu irréprimé à divers étapes de progression. La prise en compte des résultats décrits dans ce document contribuera de manière significative à la mise en œuvre réussie du RLBSP au Canada.

Les directeurs généraux (DG) du Centre des sciences pour la sécurité de Recherche et développement pour la défense Canada (CSS RDDC), Sécurité publique Canada (SP) et Innovation, Sciences et Développement économique (ISDE) ont tous un intérêt très marqué dans le contenu et les résultats de ce rapport scientifique, ainsi que le Groupe de travail multinational de l'interopérabilité fédéral/provincial/territorial (MIWG F/P/T IWG) du RLBSP qui a été élargi pour y inclure les municipalités et les trois services.

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1 Introduction

The wireless public safety broadband network (PSBN) will be a nationwide cellular network primarily for public safety, security and defence communities. It will be a transformational capability that will revolutionize the way first responders and defence personnel communicate and share information with one another for decades to come. Putting broadband mobile in their hands will greatly increase their ability to anticipate, respond to and recover from emergencies, disasters and acts of terrorism by increasing their situational awareness, which will ultimately help protect and save lives, limit property damage and loss, and make communities safer. Indeed, while commercial cellular service is able to deliver broadband to public safety users for day-to-day use, it quickly becomes unavailable when major incidents occur and networks become severely congested. The PSBN will address this by ensuring that public safety users have access to their broadband applications and services when they need them most during disasters, emergencies and large planned events.

How the PSBN can be used during the various stages of a disaster such as a wildland/urban interface fire is described in this report. The effectiveness and value of the PSBN is compared to the current state of public safety wireless communications that consists of land mobile radio (LMR) and commercial cellular service. A theoretical wildland-urban interface fire use-case is devised to support such a comparison.

Section 2 describes the use-case scenario. Section 3 compares the use of LMR and commercial service to PSBN at various stages of advancement of the fire. Section 4 describes the impact of the PSBN on the response to the incident and Section 5 provides a conclusion.

2 Use-case scenario

Southeastern British Columbia is characterized by heavily forested areas, mountainous terrain, and valleys. There are large expanses of protected parklands. There is farmland along the valley floors, and logging operations on the hillsides and further into the interior. Although the population density of the region is relatively low, there are important pockets of populated centres that contain commercial, social, recreational, and cultural infrastructure typical of larger urban centres. The area that is the subject of this use-case is illustrated in Figure 1. The Columbia River flows on the left side of the circle with numerous pockets of population along its shores.

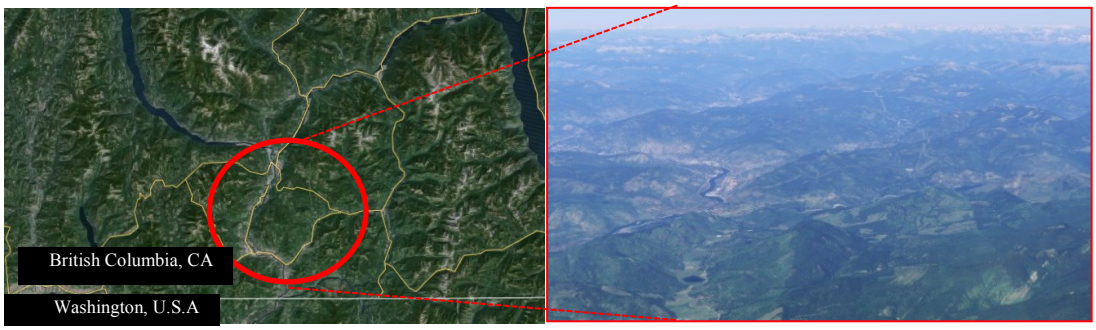


Figure 1: *Location of the use-case.*

BC Hydro operates two power generation plants and one electrical substation in the area of interest. Electricity is delivered to consumers overhead on utility poles. Freight is transported by rail, which crosses the region. There are several fibre-optic cables that are buried along the rail lines, some of which are owned by major Canadian telecommunications carriers. Local phone and Internet service is distributed to the municipalities and surrounding rural areas spanning from the fiber-optic add/drop points of presence. Typical distribution is overhead on the same utility poles that are used to distribute electricity.

Commercial wireless service providers operate a number of cell sites in the area of interest and aggregate the traffic to their fibre points of presence. The largest centre with a population of 8,200 inhabitants covers 18 km². It is served by two cell sites shared by two cellular operators. The greater region has a population of 16,000 people. Four other cell sites on hilltops provide cellular service to cover the more rural areas and the roads that traverse them. They are spaced between 5 and 20 km apart[1]. Cellular coverage beyond the roadway corridors typically penetrates a few hundred metres and no cellular service is available in wilderness areas. The BC Ministry of Forests, Lands & Natural Resource Operations (MoFLNRO) operates a VHF land mobile radio (LMR) service in the area. The RCMP uses a VHF LMR system that covers populated areas and roadways. Logging companies use recently dedicated radio channels on resource roads[2].

[1] By comparison, cell sites in urban centres are spaced less than 2 km apart.
[2] Industry Canada announcement: http://news.gc.ca/web/article-en.do?nid=854049.

The progression of a significant wildland-urban fire incident at five key points in time and the ensuing emergency response events and activities are described in the following sections. The relative effectiveness of the available communications that exists today is compared to the same communications capabilities though in this case, it is complemented by a public safety broadband network (PSBN) component.

3 Incident timelines

3.1 Time = T minus 1 (pre-incident)

As a baseline for this use case, T minus 1 considers the day-to-day operations of emergency responders and other public safety personnel and how they are supported by communications tools that consist of LMR and broadband wireless voice and data services. LMR has been used by emergency responders for decades and, to this day, it is the go-to technology for "mission-critical" voice services because LMR devices and infrastructure are designed to higher standards of reliability and availability than commercial cellular networks. Broadband wireless service is a relatively new tool for emergency responders that allows them to access applications that improve the effectiveness in conducting missions and improves the productivity of administrative tasks. Examples of typical day-to-day applications are Computer-Aided Dispatch (CAD), Records Management System (RMS), access to incident-scene video, access to criminal databases and other records, real-time license plate reader, AMBER alert images, e-ticketing, and much more.

Understandably, the availability of these communications tools depends to a large extent on the topography of the territory, the physical medium that a radio signal must travel through, and the geographic density of the wireless infrastructure. Hilly and mountainous terrain creates coverage gaps and radio shadow regions. Concrete walls, large buildings, underground facilities, and windows with metalized laminations attenuate radio signals. Radio signals decay as a function of distance so a radio receiver that is farther from the transmitter receives a weaker signal than a receiver that is closer to the transmitter. Since emergency responders are expected to operate in all types of geographic and physical environments, their ability to access communications services varies over the full range of environments.

Band-class 14 has been identified by the Government of Canada for use by public safety[3], and it has certain features that help improve the availability of communications as compared to commercial cellular. It is the only frequency band that has been approved by the 3GPP[4] to operate at two power levels. The low (normal) power level is the same as that which is approved for all the other bands. The high power level is intended for vehicular repeaters or other platforms that have a supplementary power source. The high power option would drain the battery of handheld devices more quickly, and therefore has more challenges to becoming available in this form factor. A PSBN vehicular repeater or terminal would allow emergency responders to access broadband data services further away from the cell site than would commercial cellular. Radio shadow regions would be smaller in area and fewer in number.

Furthermore, when emergency responders use wireless services from commercial mobile network operators, the data traffic they create or consume may need to be protected in a manner that is more secure than the level of protection that is offered to the general population. One common approach is to create virtual private tunnels within a shared communications channel. While such techniques, known as Virtual Private Networks (VPN), raise the level of protection for information, they also hinder interoperability by limiting the flexibility of sharing information

[3] Band-class 14 covers 788 MHz–798 MHz in the uplink and 758 MHz–768 MHz in the downlink.
[4] The 3GPP is an international standards development organization that is responsible for the LTE standards world-wide.

between agencies when it is warranted. It is expected that the PSBN infrastructure would be managed within a trust environment whose boundaries are defined by the security policies of the PSBN. As such, the occasions when VPN is required on the PSBN would be significantly reduced to protecting only highly sensitive information. As a result, information could be much more easily shared between emergency responders when warranted and as authorized.

3.2 Time = T0 (Day 1 0830h)

It has been an abnormally hot and dry summer in southeast BC and the opportunity for fire is abundant. Lightning ignites a forest fire. The fire is located in a heavily timbered area, within 5 to 10 kilometres of several major towns to the east and north, and 10 km north of the Canada-US border with Washington State. At 8:30 am a passing motorist notifies the 1-800 Provincial Fire Reporting Centre (PFRC) about the fire outbreak. He captures a video clip of the scene with his smartphone and sends it to the PFRC. The video clip has a GPS tag embedded in the file. The PFRC uploads the video clip onto a cloud-hosted situational awareness tool that is used to share information of incidents across all the various disciplines that are called to respond to the incidents.

3.3 Time = T1 (Day 1 0900h–1230h)

The fire is estimated to be about five hectares in size. The PFRC passes on all available information to the Wildfire Management Branch's (WMB) Regional Fire Centre (RFC) via Internet and voice call. As a function of the predicted fire behavior, resource availability and values at risk, air tankers and an initial attack crew (IAC) is quickly dispatched. Simultaneously, the RFC alerts the local emergency services via a voice call and email alert. Local police, fire and ambulance services are contacted by their dispatch centres and are immediately placed on standby. The local municipal emergency management organization activates its Emergency Operations Centre (EOC) and notifies the nearest Provincial Regional Emergency Operations Centre (PREOC) via a voice call and email alert. The PREOC alerts its Provincial Emergency Coordination Centre (PECC). After logging into the provincial emergency management information system, both the PREOC and local EMO set up new event portfolios to record incidents, coordinate outside resource requests, and provide status updates to municipal and provincial elected officials and administrators. The PECC opens a project space in their province-wide real-time multi-agency situational awareness system[5] to facilitate sharing situational awareness (SA) information that is relevant to the incident. User accounts to enter data and access SA information via this application are created. The PECC monitors social media for any credible information or insight that may indicate a risk to people, property, or critical infrastructure.

The RFC, EOC, PREOC, and PECC are located away from the incident area. Their locations are not at risk from the fire. They maintain power and access to land-based broadband Internet service throughout the incident. The cell sites that serve these locations are outside the incident area.

[5] The real-time multi-agency situational awareness system allows registered users to enter public safety-related, geo-coded information into a database that can be visualized with various layers on digital maps. The types of information that can be recorded on this system are location of road closures, fire perimeter, wind speed and direction, location of critical assets, location of people, etc. Each one is represented by an icon. Text, images and video clips can be tagged to each icon. The database is hosted in the cloud and therefore a connection to the Internet is required. When a user adds, changes, or deletes information, within seconds it becomes visible to all the other users. MASAS is an example of such a tool (www.masas-x.ca).

While en route, and as more information becomes available, the IAC is kept appraised of the SA information and is shared with other authorized emergency services and stakeholders. These stakeholders include police, fire, emergency medical, health officials, BC Hydro, rail system operators, NGO's, local government authorities, provincial and federal government ministries, and military. Due to the proximity of the fire to the US border, Washington State and U.S government officials are also notified. A total of 22 agency representatives are participating.

Table 1: *T1 – State of communications and response capabilities.*

Key events: *Emergency management and coordination centres are activated; Incident Command System (ICS) roles are assumed; stakeholders are alerted and on standby; IAC is en route. Internet and commercial wireless networks are operating normally. No power outages.*	
LMR and commercial cellular	**LMR, commercial cellular, and PSBN**
Incident information is populated on the SA application using an Internet connection and distributed to the IAC and other organizations from the EOC. A multi-party audio/video conference is initiated by the PREOC to enable key stakeholders to be briefed and to coordinate strategic planning. While en route to the fire, the members of the IAC view the original video clip submitted by the passing motorist to the PFRC. They download the video clip onto their devices so they can access it when they are outside of cellular coverage.	Incident information is populated on the SA application using an Internet connection and distributed to the IAC and other organizations from the EOC. A multi-party audio/video conference is initiated by the PREOC to enable key stakeholders to be briefed and to coordinate strategic planning. While en route to the fire, the members of the IAC view the original video clip submitted by the passing motorist to the PFRC.
IAC location is tracked in real-time by GPS as they travel on public roads. When the IAC turns onto resource roads, they lose commercial cellular service. The IAC then reverts to LMR and calls in its GPS coordinates periodically to the EOC over radio. The EOC plots the location on the digital map of the SA application. Since the IAC no longer has access to real-time visual information regarding the fire, the EOC communicates a verbal description over LMR radio to the IACL. The IACL interprets the information and relays it to the members of his team.	IAC location is tracked in real-time by GPS as they travel on public roads. When the IAC turns onto resource roads the high power PSBN modem in their vehicles maintains a broadband connection to the PSBN allowing the EOC to continue tracking the IAC vehicles in real-time[6].
A support aircraft collects heat profile data and photos of the fire zone that is populated on the SA application along with other relevant information.	While travelling on resource roads the IAC continues to receive geo-tagged video and textual information using the SA application.

[6] The 3GPP has specified a high power option for the public safety frequency band only that allows longer range and higher capacity. This option is not intended for commercial frequency bands.

The various emergency management centres and U.S stakeholders are able to view this information using the SA application within 10 seconds of being posted. However, since the IAC is travelling on resource roads, they are no longer able to access the SA application. The EOC updates the IAC with verbal descriptions over LMR radio.	The SA information includes location of critical infrastructure and other assets displayed on a topographic digital map. Wind direction and speed is overlaid on the map. The heat profile data of the fire zone is collected by the support aircraft and populated on the SA application along with photos of the area. All stakeholders, including the IAC, are able to access this information within 10 seconds of being posted.

3.4 Time = T2 (Day 1 1230h–Day 2 0830h)

PREOC personnel conduct a simulation to predict the spread of the fire in order to help determine where to locate the Incident Command Post (ICP). It is determined that the ICP can be located at the Provincial Parks administration office 4 kms from the fire. The office has phone and slow Internet service delivered over utility poles. Commercial cellular service is marginal (no signal in the building, one bar outside on the northwest side of the building).

At the incident site level, the Initial Attack Crew Leader (IACL) provisionally assumes the role of Incident Commander (IC) and is responsible for all critical decision making related to fire assessment, strategic planning, requesting and supporting resources, and operational implementation, tracking and financial management of resources using the Incident Command System (ICS). Four other officers are assigned to the ICP—operations, planning, logistics and safety. The initial ground crew consists of 16 firefighters, supported by two air tankers and one helicopter with a water bucket. The operations team installs a portable 5 KW thermoelectric generator as standby in case power fails at the park administration office. The generator is sufficient to power the on-site lighting, communications equipment, battery chargers, and computing platforms.

Due to the increasingly aggressive nature of the fire, fanned by wind gusts, the fire is spreading rapidly (now 175 hectares). By 12:30 pm the ground crew strength has grown to 36 firefighters divided into two attack crews, each led by a captain. It is now apparent that the fire could quickly overrun fireguards prompting a request for more attack crews. By dusk the fire has grown to 400 hectares and is now within 2.5 kms of municipal neighbourhoods. Planning begins for the integration of the municipal fire services along with the formation of a unified command operation at the Incident Command Post (ICP). The local municipal fire service activates its mutual aid agreements with other area communities. At the EOC plans are activated to initiate the evacuation of residents and campers in the threatened areas. NGOs prepare shelters to register and receive evacuees. Search and Rescue (SAR) teams are organized and on standby to conduct door-to-door checks as well as at campgrounds.

Table 2: *T2 – State of communications and response capabilities.*

Key events: *Fire is spreading; additional ground crews are dispatched; unified command is installed in the ICP; nearby communities are requested to send reinforcements to combat the fire; NGO staff is mobilized and evacuation shelters are prepared. SAR teams are organized. Internet, phone services, and commercial wireless networks are operating normally. No power outages.*	
LMR and commercial cellular	**LMR, commercial cellular, and PSBN**
ICP communicates with the attack crew captains via LMR since commercial cellular service is not available at its location. Commercial cellular service is also not available at the locations of the attack crews.	The operations officer at the ICP installs a portable high power PSBN modem outside the building that creates a high speed WiFi communications bubble for the ICP. The WiFi service allows the ICP to operate with high speed access to the Internet and various multimedia applications.
	The vehicles of the attack crews are equipped with high power PSBN modems that maintain broadband connections to the PSBN core network and the Internet. Thus, the attack crews access all of the same multimedia tools available to the ICP and other stakeholders. The vehicular PSBN modems create high speed WiFi local area networks for at least 100 m around the vehicles allowing attack crew captains to use WiFi-enabled devices outside the vehicles.
	All the firefighters are equipped with PSBN devices that support Proximity Services (ProSe)[7]. ProSe allows the firefighters to operate up to one km away from the vehicles while remaining connected to each other and to the PSBN.

[7] Public safety proximity services allow users to communicate with each other without connection to the PSBN base station. This was standardized by the 3GPP for Band 14 public safety. A similar function was standardized for commercial cellular but unlike public safety proximity services, requires the base station to set up and terminate the communications sessions. Hence, for commercial cellular it is intended to off-load traffic from the base station whereas for public safety it is intended to allow users to communicate when they are disconnected from the base station.

Due to the increasing number of participants and since the LMR channels are shared resources, protocols to minimize "radio chatter" are employed. This means that pre-established messages and codes are used to minimize the time that a channel is occupied for a session. This prevents conversational style interactions, increasing the risk that important situational details are not effectively shared among responding agencies.	ICP and attack crew captains exchange verbal information using high definition voice[8] over PSBN.
The ICP updates SA information and they access updates posted by aerial support team in real-time via the slow Internet service that is operating at the park administration office. They relay new information to the attack crew captains over LMR radio and they upload the information reported by the captains to the SA application. The attack crews use paper maps since they cannot access the SA application. The captains use their LMR radios to verbally report their status, coordinates, and descriptions of the fire and fuel conditions. The captains receive weather updates and predictions of fire perimeter development over the radio.	The attack crew captains upload new information from the field to the SA tool and they access updates posted by aerial support team in real-time. The attack crew captains access the SA application to view updates. The digital map indicates the locations of all the attack crews, critical infrastructure, and other assets in real-time. The attack crew captains participate in a multi-party audio-video conference with the ICP, the EOC, and the PREOC to view and discuss the implications of the simulation of the spread of the fire that was performed using the latest weather updates and fuel conditions photographed by the attack crews.

[8] High Definition (HD) voice is also known as wideband audio and uses the Advanced Multi-Rate – Wideband (AMR-WB) codec that covers 50 Hz to 7,000 Hz audio spectrum. It delivers higher quality and more natural-sounding voice than public switched telephone service (300 Hz to 3,400 Hz). The ultimate in high definition voice is available on LTE since 2014. The standard for that codec is known as Enhanced Voice Services (EVS), which covers 50 Hz to 14,000 Hz audio spectrum. The most common North American standard for LMR is P-25. The latest codec standard for P25 is the Advanced Multi-Band Excitation (AMBE+2) codec. The Mean Opinion Score (MOS) test for P25 shows significantly worse audio quality than AMR-WB.

The commercial cellular base stations serving the affected area are experiencing greater traffic loading reflecting heightened anxiety among the residential and commercial subscribers. Fire fighters, utility workers, NGOs, SAR, medical personnel, municipal workers, news reporters, and personnel from various government agencies converge to the affected area putting additional loading on the commercial cellular base stations. Three out of four call attempts are not successful. Emergency workers that are registered for Wireless Priority Services (WPS)[9] initially experience an average of five minutes wait time before a cellular channel is freed. But as more callers hold the cellular channels open for fear of not being able to get a channel later, the wait time for a dial tone for registered WPS subscribers increases to 15 minutes on average.	Public safety agencies and support personnel are authorized to use the PSBN to communicate with each other using voice and multimedia applications. They are selectively authorized to access different information networks. As the number of users grows and more information is sent between end points using the PSBN, bandwidth demand peaks in a manner that exceeds the capacity of the PSBN. In such instances, priority and quality of service (QoS) mechanisms are enabled in the PSBN that allow a policy-driven allocation of radio resources during periods of congestion. The rules assert priority and QoS to users and applications according to the needs of the incident. Furthermore, by not carrying public safety traffic on the commercial cellular networks, there is more capacity available on those networks to serve the public.
The Safety Officer at the ICP receives periodic reports from the attack crew captains on the levels of physical stress of the firefighters as perceived by the captains.	The firefighters are equipped with PSBN communications devices that support ProSe. The devices have GPS and Bluetooth capability, which connects to the body sensors of the firefighters. The attack crew captains and Safety Officer at the ICP monitor in real time the physical stress level indicators (e.g. heart and respiration rates) of the firefighters and their locations.
PECC prepares briefs for elected officials to inform the public and media on the status of the incident. Whereas the PECC public relations official can get the information she needs from the SA application, she is concerned about the accuracy and age of the information since it is updated in part by the IC interpreting what was said to him from the attack crew captains. She therefore contacts the various stakeholders to get updates and cross-references what they tell her with what is recorded in the SA application.	PECC prepares briefs for elected officials to inform the public and media on status of the incident. The public relations official draws her information from the SA application. She trusts the content because the PSBN allows for real time updating of the SA by public safety authorities, and there is no person in the middle interpreting the events and recording them on behalf of the attack crews. Hence, her media postings are consistent with what other stakeholders are tweeting.

[9] In Canada, Wireless Priority Service is only offered by Rogers Wireless on its 2G network on a per-fee basis.

3.5 Time = T3 (Day 2 0830h–Day 3 0830h)

It is now the morning of the second day of the fire. As the result of a localized afternoon lightning storm on the previous day, new fires have been reported in the vicinity that are being pushed by 75 km/h winds and gusting downdrafts in steep terrain carrying burning debris 6 to 8 km from the fires. The fires are moving along three fronts and are expected to converge with the current fire to produce a potential major firestorm. Many utility poles have burned resulting in loss of power for several towns, including the ICP. The ICP switches to the 5 KW thermoelectric generator to power lighting, communications systems, and battery chargers. Two commercial cell sites are operating on backup power that will run out in eight hours. When its reserves run down commercial cellular service and the PSBN service from those sites will be off. The impact will be no cellular service along the roads that interconnect the municipalities and for 35% of the major municipality in the region. One LMR site that is shared by the RCMP, MoFLNRO and logging companies is running on backup power, but because that site is hardened to stricter public safety standards, it can operate for 72 hours on backup power. When the fuel in the generator runs out, there will be no LMR service for 50% of the incident area. Internet is off-line due to the loss of power to the gateways, routers, and access points. The telephone central offices are on backup power with capacity for eight hours. When the batteries run down all landline phone service for incident area will be down.

Unified command with WMB and the municipal fire departments is initiated. A simulation of the fire perimeter and direction indicate that there is a significant probability that the fire will present a high threat to two towns, an electrical substation, and a major rail line. In addition, two cell sites and one LMR station are also at risk of being destroyed. The model predicts that the fire has a high probability of crossing into the State of Washington, which is corroborated by an independent simulation conducted by the US Forest Service. The State mobilizes attack crews to clear firebreaks in WA and sends other attack crews to augment the operational teams on the ground in BC. They are placed under the direction of the IC. The IC redirects some attack crews to protect the cell sites, LMR station, and electrical substation.

Several evacuation alerts and orders are issued during the day. RCMP clear the evacuation routes of non-essential traffic, provide priority movement for ambulances and other emergency vehicles, and ensure an orderly evacuation. They set up roadblocks to restrict access to the evacuated areas. SAR personnel sweep the camp grounds to evacuate the campers and go door-to-door to make sure that everyone under the evacuation order has left. By dusk, over 3500 people have been evacuated. RCMP provide security for material and supplies at storage sites, staging areas, and during its distribution.

The IC requisitions the deployment of ruggedized self-contained LMR repeaters to be installed at key locations to extend LMR coverage from more distant LMR stations that are not at risk from the fire. Personnel from MoFLNRO airlift the equipment and install them before the affected LMR site runs out of power.

Due to a busy fire season throughout the province, WMB is unable to provide additional firefighters from its own roster and requests assistance from Alberta, Ontario and California. Similarly, the municipality places a request via the Provincial Fire Commissioners Office for assistance from fire departments around the province. BC Ambulance, RCMP, local SAR and other agencies are also requesting resources from elsewhere in the province. CBSA is advised that requests for support to the states of WA and CA have been issued. The states' emergency managers supply a roster of their attack crew members and assets to CBSA and the PECC. CBSA pre-clears the foreign nationals prior to their arrival at the border to speed their passage.

Table 3: *T3 – State of communications and response capabilities.*

<table>
<tr><td colspan="2">Key events: Fire threatens private property and critical infrastructure. Fire spreading to U.S is predicted with high degree of certainty. Command structure increases in numbers. Request goes out for interprovincial and international assistance to fight the fire. States of WA and CA send attack crews to assist in BC. Alert messages are broadcast on radio, television, and to cell phones. 3,500 people are evacuated. Commercial cellular service and LMR are operating on limited backup power. Portable LMR stations are installed. No internet service. Phone service to areas outside of core centres is down, otherwise operating on backup for the rest of the area. No power except where emergency backup facilities exist.</td></tr>
<tr><th>LMR and commercial cellular</th><th>LMR, commercial cellular, and PSBN</th></tr>
<tr><td rowspan="2">There is no Internet or phone service at the ICP and all communications with stakeholders is conducted via LMR.</td><td>ICP is able to connect with the Internet and has high definition voice service. SA application is online. The ICP Safety Officer continues to monitor physical stress levels and real-time locations of the attack crews.</td></tr>
<tr><td>Since the PSBN base stations in this rural area share the same sites as the commercial cellular systems, the terrestrial-based PSBN service will also shut down when the backup power runs down. The IC therefore requisitions 6 deployable PSBN systems to provide broadband service to cover the incident area. Each deployable system (DS) is contained in two ruggedized cases and is transportable by all terrain wheeled vehicles or by helicopter. Each DS consists of a 20 m guyed telescopic mast, a small aperture satellite dish antenna, electronics that self-aligns the satellite dish, electronics for the PSBN, and solar powering system with batteries. The DS can also be powered from a vehicle’s battery.

The Communications Leader (COM-L) determines the most suitable locations for the DS to optimize coverage while being out of danger from the fire. The simulated coverage prediction reveals coverage gaps in deep remote valleys. He uploads the coverage map and alerts the attack crew captains to be aware of the PSBN coverage gaps. The IC contacts the air traffic controller to overfly the gap areas using the support aircraft approximately every two hours. The support aircraft are equipped with PSBN repeaters that can extend the coverage of the DS beyond their horizon.</td></tr>
</table>

The WA and other Canadian mutual-aid attack crews' LMR radios are pre-programmed to the same channels that are in use at the incident. But the California attack crews' radios are not. They are submitted to the Communications Tech (COM-T) at the ICP to be re-programmed.	The roster of mutual aid attack crews is submitted to the COM-T to admit their credentials to access incident-level information resources, such as the SA application, coverage map, and a list of LMR channel assignments. The out-of-province attack crews can use the same PSBN devices they use in their home jurisdictions, whether that is another province or the U.S.
The commercial cellular network is deluged with call attempts as the land-line service has partially failed due to the destroyed utility poles. Emergency workers compete with commercial subscribers for access to cellular channels. The number of emergency 9-1-1 calls made over cell phones increases, which is going to fail when the power runs down in eight hours. The commercial wireless operators do not prioritize E9-1-1 calls. Hence, emergency call attempts by citizens are repeatedly blocked due to WPS loading from emergency workers using the commercial cellular service and an abnormally high number of users attempting to make cell phone calls.	The PSBN spectrum is shared with commercial wireless carriers with priority and pre-emption privileges for public safety[10]. By agreement, E9-1-1 calls that are carried over the PSBN are not pre-empted. While the commercial wireless service is now overloaded due to the degraded land-line service and increased cellular call attempts, the PSBN's priority and quality of service (QoS) mechanisms are managing the demand on the PSBN in accordance with predefined policies. Protocol allows the IC to dynamically adjust the priority and QoS settings in accordance with the nature of the incident and the makeup of the population that is responding to the incident. The COM-L at the ICP is able to determine how the PSBN's radio resources are being utilized via a graphical user interface. He is alerted to an increase in demand for radio resources consistently passing a trigger point, thus requiring action from the default settings. He adjusts the PSBN controls available to him to ensure that mission critical applications are not impacted.
Some attack crews are assigned to protect the electrical substation and cell sites. Fire suppression from aerial tankers is coordinated with the attack crew captains. Information from aerial reconnaissance indicates which resource roads are impassable and uploads this information to the SA application. But since the ICP and attack crews are not able to access this information, the EOC contacts the ICP by LMR to inform the IC of road closures. The IC plots this information on his paper maps. Then, the ICP contacts the PREOC to screen the road	The attack crew captains that are assigned to protect the electrical substation and cell sites use the SA application to determine the best approaches to reach them using the topographic and road layers on the SA application. The SA map has road closure information, which the aerial surveillance team has identified. One attack crew has the option of a shorter road or a longer road to reach its assigned target. But the PREOC's simulation of the fire behaviour predicts that taking the shorter route would expose the attack crew to a high risk. The

[10] This scenario assumes that Industry Canada allows the public safety spectrum to be shared with commercial wireless operators.

options against the simulated fire behaviour. For one of the attack crews, the PREOC advises against using the shortest path because the model predicts that the attack crew may become stranded with no exit. The IC informs the attack crew captains of the routes to take. The attack crew captains mark their paper maps and head off to their targets. All the communications involving the IC or the attack crews is conducted by LMR.	simulation result is visible on the SA application and the otherwise open riskier road is flagged as a danger for the attack crew captains and the IC to see. All parties are aware of the situation immediately. There is no interpreting and no delay.
A group of firefighters becomes separated from their crew and cannot locate each other. The attack crew captain contacts them by LMR and they exchange their GPS coordinates. The captain plots it on his paper map and the firefighters' GPS navigation guides them back to rejoin the crew while remaining in contact with the captain.	A group of firefighters become separated from their crew and lose data connection to the PSBN. Their PSBN devices emit an audible alarm. The attack crew captain receives a similar alert. The PSBN devices display the last recorded location of the firefighters before their devices disconnected from the PSBN. The disconnected firefighters and attack crew captain resort to LMR to communicate. As other firefighters approach within 1 km of their location, the devices re-establish a connection to the PSBN network by virtue of ProSe. Their location is immediately updated on the SA application.
The State of WA has pre-programmed its LMR stations on its side of the border to operate on the cross-border mutual-aid radio channels.	The State of WA deploys two public safety LTE Systems-on-Wheels (SOW) near its border with BC to augment PSBN coverage and capacity along their shared border. Their SOWs are connected to the FirstNet network in the U.S. via satellite backhaul. Since the public safety broadband networks operate on the same frequency band in Canada as in the U.S, Canadian emergency responders are able to connect through the U.S SOWs for those responders that are in proximity to the border[11].

3.6 Time = T4 (Day 3 0830h–Day 6 0830h)

During the next 72 hours the fire spreads to over 12,000 hectares and into the community. More than 10,000 people are now evacuated. 360 homes and other structures are lost. Logging operations and other commercial activity is interrupted. Valuable timberland is lost. Smoke from the fire has drifted into communities that are not at risk from the fire, but hospitals in these communities have seen an increase in cases of respiratory distress. Citizens are advised to stay indoors impacting the lives of people far from the incident area. People displaced from their homes are either in shelters run by the NGOs or are hosted by family and friends.

[11] This assumes that a roaming agreement is in force between FirstNet and the Canadian operator(s) of the PSBN.

Firefighters suffer fatigue and exhaustion and as a result are more prone to injuries. Injured firefighters are evacuated and taken to nearby medical facilities. Access privileges to private medical information of the firefighters is pre-arranged so that EMTs and the attending physicians can determine what medical acts can be performed on each individual. Access to medical records is granted only for injured firefighters.

Four campers are unaccounted for and are thought to have headed into the back-country shortly before the fire had started.

At the height of the tactical response (now five days into event) over 550 firefighters are involved in each shift along with support personnel from 16 other agencies. Personnel and equipment are drawn from over 30 fire departments across BC, contractors and loggers. Other responders include 47 police officers, 26 Search and Rescue members, 22 paramedics, 44 utility and municipal workers (shutting off / restoring service), 3 coroners, 67 contractors (subject matter experts, fuel and material suppliers, food and other logistics support). 1,400 members of the Canadian Armed Forces (CAF) are being moved in to assist in the mop up as fire crews begin to rotate out. A representative of CAF is in the unified command post.

Table 4: *T4 – State of communications and response capabilities.*

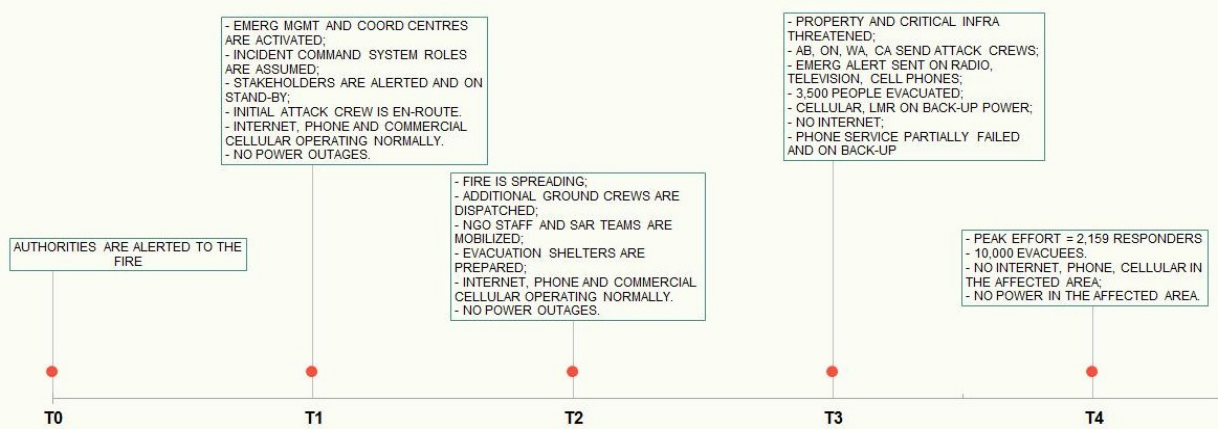
Key events: *Fire threat has peaked. Casualties have occurred. No Internet, phone, or commercial cellular services in the affected area. No power in the affected area.*	
LMR and commercial cellular	**LMR, commercial cellular, and PSBN**
There is no Internet or phone service at the ICP and all communications with stakeholders is conducted via LMR.	ICP is able to connect with the Internet and use high definition voice services. The SA application and other tools are online. The ICP safety officer continues to monitor physical stress levels and real-time locations of the attack crews.
Attack crew captains call in medical assistance for injured firefighters by LMR radio. The more severely injured are transported to the nearest burn unit. For the period when the ambulances are out of range of an operating cell site, the paramedics use LMR radios to communicate with physicians, describing the conditions of the firefighters and receiving instructions. The ambulances enter an area where there is cellular service 20 minutes after having collected the injured firefighters. But despite being WPS subscribers, they wait 10 minutes before they obtain a cellular dial tone. Since WPS operates on 2G and they have only 2 bars of reception, they get about the same speed as old fashioned dial-up modems, which is about 56 Kbps. That is not enough for audio-video conferencing.	The ICS Safety officer continues to monitor the physical stress levels of firefighters. She alerts the attack crew captains of the individuals at risk, and out of precaution, the at-risk firefighters are rotated out of the hot zones. Attack crew captains call in medical assistance for injured firefighters. An attending physician is alerted to expect injured firefighters. He logs in to the bio-sensor monitoring application and the attack crew captain sends live streaming video for the physician to get a visual indication of the extent of the injuries. Before the EMTs arrive, the physician has determined that two firefighters must be evacuated by air to the nearest burn unit. A med-evac team is dispatched by air. The pilot uses the SA application to determine the best location to land and coordinates with the

Remote monitoring of vital signs is frequently interrupted due to buffering of the data and is therefore unusable.	EMTs that are en route where to rendezvous with the ambulances transporting the two critically injured firefighters. As all the firefighters are en route to their respective medical facilities, the emergency medical technicians (EMT) engage in an audio-video conferencing session and remote monitoring with the attending physician to stabilize them and begin administrating emergency medical care. The PSBN priority and QoS mechanisms treat this information stream with high priority. The EMTs and physician access the firefighters' medical records from the health databases of the various jurisdictions from which they hail.
Despite having cell phones and solar battery chargers, the four back-country campers were unable to signal for help due to lack of cell phone coverage in the back-country. Search and Rescue personnel were dispatched to their last known location with equipment able to detect cell phone transmissions over a few hundred meters[12]. The hope is that the cell phones are still active as the SAR teams try to find them. Unfortunately, the fire is progressing and there is no way to direct them to safer areas while the SAR teams search for them. The SAR teams themselves are exposed to greater risk the longer they are on the ground.	Evacuation alert messages continued to be broadcast on radio, television, and cellular networks. The PSBN was also used to broadcast evacuation alert messages. The four back-country campers received the alert messages on their cell phones from the PSBN DS. They were able to make an E9-1-1 call over the PSBN to notify the authorities of their whereabouts. Their cell phones reported their GPS coordinates with an uncertainty of 30 m and with the help of the SA application; the SAR team leader is able to direct the campers to a black zone where they would be safe until the SAR team is able to extract them.
Canadian Armed Forces (CAF) are sent in to areas where the active fires have been suppressed to look for hot spots. Aerial reconnaissance with infrared cameras detects hot spots and their locations are communicated to the IC over LMR. The CAF liaison at the ICP directs CAF platoons to those locations. He communicates this information to them by identifying coordinates on a map.	CAF lieutenants are equipped with PSBN-compliant user devices for use in domestic operations so they can be interoperable with other agencies that are engaged in the response. The roster of PSBN users from the CAF is communicated to the COM-L using a predefined format while they are en route to the incident area. The COM-L performs a group drag-drop action that grants access control privileges to dozens of lieutenants and their superiors to the SA application and other incident-specific information networks. The aerial reconnaissance personnel locate hot spot icons on the SA map. At the ICP, the CAF liaison geo-fences designated hot spot areas and

[12] http://www.rescuecell.eu.

	assigns them to specific CAF platoons by dragging/dropping the platoon icons to the hot spot icons. CAF lieutenants locate their target areas on the SA map and electronically acknowledge the assignment to their hot spots back to the ICP.
The SAR and CAF personnel discover human remains on resource roads and on hiking trails. They communicate the locations of the corpses to the IC with their LMR radios and photograph the scenes. The Coroner is dispatched to investigate with assistance from the RCMP. The investigation reveals that the SAR teams were instructed to sweep the campgrounds and affected residences to notify citizens to leave. Records of radio communications indicate the SAR teams received the messages and acknowledged having conducted the sweeps. However, there is no objective evidence of the actual locations that the SAR teams went to.	The SAR and CAF personnel discover human remains on resource roads and on hiking trails. They mark the locations of the corpses on the specialized secure application for forensic investigations. They upload photographs and video clips of the scenes using the same application. The Coroner is dispatched to investigate with assistance from the RCMP. The investigation reveals that the SAR teams were instructed to sweep the campgrounds and residences to notify the citizens to leave. The SAR teams used a collaborative application to mark off the addresses that they visited, whether there were any people present and who they were. They did the same with the campgrounds, visiting each camping spot. In collaboration with NGOs, the application indicated the addresses of known elderly citizens and those with reduced mobility. The application tagged the location of the SAR teams at each stop. The information is stored in a secure database that preserves the chain of evidence.

The following illustrates the time line of the developments of the events related to the fire and the response to the fire. It summarizes how the communications infrastructure for citizens and emergency responders is impacted as the severity of the fire grows. The implications on the ability of the responders to protect themselves, their fellow citizens, and critical infrastructure are described. It is evident that loss of communications, whether by destruction or loss of service due to protracted power failure places lives and safety of all people in the affected area at a greater risk.



LMR + Cellular	- LMR is pervasive. - Cellular service only in populated areas and along roads.	- Cellular networks are overloaded by combined demands of citizens and responders. - Long wait for WPS dial-tone.	- Cellular and phone service failure is imminent. Citizens will be deprived of the means to communicate or to signal emergencies. - LMR emergency repeaters are deployed to maintain radio service in spite of failure of the fixed LMR site.	- No cellular or phone service. Citizens' safety is at risk. - Responder comms is only by voice. - Responders translate coordinates and status information conveyed by voice onto paper maps. Risk of errors due to misunderstanding and transcription. - Medical response teams are guided by verbal instructions. Attending physician cannot participate in triage and medical treatment until patient reaches medical centre. Patient care is at risk.
LMR + Cellular + PSBN	- PSBN coverage available on resource roads and in wilderness with high power modems.	- PSBN carries public safety traffic and applications; relieves cellular network of some loading since responders are not using the cellular network. - PSBN priority and QoS mechanisms ensure mission-critical applications are usable during periods of network congestion.	- PSBN deployable systems are dispatched in BC and WA due to imminent failure of main PSBN sites. Canadian and U.S responders can be served seamlessly by either system. - Aerial repeaters provide additional PSBN coverage to fill in gaps from portable systems.	- E9-1-1 service is supported by the PSBN for citizens to signal an emergency. - Citizens are able to receive Emergency Alerts on the PSBN in spite of failure of the cellular service. - Bio-sensors on responders and patients allow real-time monitoring by medical professionals. - Continuous tracking of location of people and assets. - Real-time assessment of the evolving risk to people, assets, and infrastructure.

Figure 2: *Timeline of events.*

4 Potential impacts of the PSBN

The presence of the PSBN has the potential to make a profound impact on the manner in which emergency responders carry out their mission, whether it is focused on law enforcement, medical services, or, as is the primary subject of this use-case, firefighting. The PSBN is an intelligent conduit connecting people, machines, and information. By virtue of the bandwidth allocated to it, the PSBN allows applications to be used that would otherwise not be possible on communications systems that have less capacity. For example, it is not possible to meaningfully stream video on the bandwidth allocated to an LMR channel. The applications are key to usability and usefulness of the PSBN. The "intelligence" of the PSBN is in the ability to allocate its limited radio resources to the demands that carry a higher priority. In essence, it offers the public safety agencies the choice of how they want to prioritize the use of the PSBN and to dynamically adjust those choices depending on the needs of the incident at hand. With supporting policies and regulations, the PSBN can serve as the underlying enabler for interoperability among emergency responders.

The principal effect of the PSBN in this use-case is demonstrated by its ability to deliver broadband communications services to emergency responders intelligently, and in adverse conditions, where other systems that are based on similar technology would fail under those conditions. The PSBN can enable the persistent use of applications that enrich the emergency responders' situational awareness, which improves the effectiveness of their response, which ultimately results in fewer human casualties, less economic losses, and faster recovery of societal structures with associated benefits for citizen well-being.

The persistence of enhanced situational awareness consisting of visual and verbal information is a key differentiator for the PSBN that removes the risk of misinterpreted information being used to guide life-and-death decisions. Additionally, the ability to convey the nuances in tone of voice and facial expression is a benefit that LMR cannot deliver.

Below is a summary of the potential impacts of the PSBN on the principal actors in this use-case.

a. Firefighters and attack crews (civilian and military):
   - Lower rate of injuries;
   - Lower risk of permanent damage resulting from injury, especially burns; and
   - Reduced risk of death[13].

b. Emergency Management officials and Incident Command team:
   - More cost effective use of human and material resources;

[13] On June 30, 2013 nineteen (19) firefighters died at the same time while battling the Yarnell Hill, AZ wildfire. The Serious Accident Report that followed attributed an important factor in their death to a 30-minute gap in communications where the Incident Commander did not know that they had left a black zone (safe location) and could not locate them. The firefighters could not have known of the danger that awaited them and became trapped by the fire. The report states that an aircraft with fire suppressant on board was in the area but the Incident Commander did not know they were in danger and, even if he had known, he would not have known the location of the firefighters to relay to the pilot [Ref. 2, 3].

- Quicker containment of the fire due to better and quicker decisions based on real-time information that is richer in content and context, and more precise inputs to predict a fire's behaviour; and
- Greater public support for actions, especially evacuations, due to clearer and consistent communications with the public based on up-to-date and comprehensive information.

c. Law Enforcement:
   - Facilitate investigations into the causes of deaths.

d. Medical personnel:
   - Conduct medical acts with less risk of unintended consequences due to knowledge of the patients' medical backgrounds;
   - Cost-effective and timely mobilization of med-evac assets due to remote triage; and
   - Greater safety of EMTs since they can determine best route to take to avoid placing themselves in danger.

e. General population:
   - Reduced mortality since PSBN could allow E9-1-1 calls to be prioritized; and
   - Reduced mortality since the deployable PSBN assets, while serving the emergency responders in the wilderness, can also be used by citizens when no other means are available to them to call for help.

f. Critical infrastructure and other property:
   - Reduced risk of catastrophic loss due to better predictions of fire behaviour and pre-emptive dispatch of attack crews; and
   - Utility poles cannot be saved due to the sheer number of them and their vulnerability.

g. Canada Border Services Agency:
   - Reduced time to process emergency responders and their equipment arriving from the U.S.

h. Canadian Forces:
   - Reduced cost of deployment due to improved coordination with civil authorities.

Below is a list of the possible uses of the ruggedized wireless devices supporting a wide variety of applications for both responders and the ICP:

- Responders at the site: Voice communication among responders and to and from the incident command*;*
- Reporting the location of the responder to the tracking display at the Incident Command Post and Regional and municipal fire control centres;
- Transmitting digital status check-ins indicating either that the responder's status is normal, or that some form of emergency or panic/man-down alert has been activated;
- Transmitting and receiving canned and free form messages and initial incident reports to the ICP;
- Downloading and displaying maps of:
  - Current location and status of all fellow responders;

- Fireline hazards and avoidance;
- Escape routes and safe zones;
- The incident area, fire behavior and direction;
- Real-time wind direction and speed over a large area; and
- Important locations such as:
  - Helipads;
  - Staging areas;
  - First aid stations;
  - Boundary information such as extents; and
  - Rivers, roads, contours, and critical infrastructure.

- Manipulating maps with basic commands such as pan and zoom;
- Capturing and transmitting imagery of the fire behaviour and resultant damage to key areas;
- Annotating and marking up maps and transmitting them back to the ICP; and
- Displaying real-time imagery of the incident area relayed by overhead aircraft.

At the ICP, in addition to possessing the same capabilities as responders, incident commanders are also able to use portable and mobile wireless devices for:

- Full resource (including air tanker support) and personnel tracking using local and remote servers;
- Requests and data sharing with all key local responders and out-of-area strategic support centres necessary to support ICS functions;
- Manipulating GIS and earth observation products downloaded from remote servers;
- Domain specific applications and organization specific applications such as weather, fire behaviour tools, etc. These may run locally but require network connection to access and process real-time updates; and
- Data management / warehousing of all data collected for the specific incident by responders (especially when the backhaul network may be congested or possess limited capacity).

4.1 Assumptions

The following assumptions have been made while formulating this use-case:

- The use of a hypothetical wildland-urban interface fire use-case can effectively be used to reveal the potential impact of a PSBN in such an incident;
- For economic reasons the PSBN shares the same sites as the commercial cellular operators in rural areas;
- The ICP uses a satellite broadband connection as backup to the existing terrestrial PSBN in the event local terrestrial backhaul is damaged or destroyed;

- Personnel arrive from multiple local and out-of-region/province agencies under mutual aid agreement and through request to provincial EMO;
- Communication is required inside and among agencies without further licensing;
- Communication will be able to take place between PSBN and non-PSBN users as required and authorized;
- The PSBN can be used for emergency 9-1-1 calls from the public; and
- All devices that can access the PSBN support Band 14 operation.

4.2 Actors

The following actors could all potentially be involved in the described interface fire.

BC Govt. Wildfire Mgt. Branch (WMB)

- Operations
- Planning
- Logistics
- Finance
- Safety
- Information
- Agency liaison
- Unified Command at single command post
- Suppression operations & support, both land and air
- Responder safety
- Damage & impact assessment
- Integrated land management planning with agencies & stakeholders where applicable
- Evacuation boundary and route planning
- Media management

U.S firefighters

- Suppression Operations
- Fireguard clearing

Local Fire Depts. (FD)

- Unified Command at single command post
- Suppression Operations & Support
- Responder safety
- Mutual aid coordination
- Evacuation boundary and route planning
- Media Management

Police

- Operational Branch for evacuation & security

Search and Rescue

- Assist police in evacuation

Ambulance

- Medical Transport

Local Govt. EOC

- Provide support & policy direction to site (note—EOC does not provide tactical direction to site)
- Evacuation boundary and route planning
- Public alerting; evacuation orders
- Setting up reception centres
- Damage assessment, relief and recovery

Local Government—public works

- Assisting with road closures and local water services

Utilities—power, gas, water, etc. (critical infrastructure)

- Attend site to protect their assets
- Shut down and/or restore services
- Attend EOC in agency liaison role

EMBC Provincial Regional Emergency Operations Centre (PREOC)

- Coordinate higher level situational awareness among all stakeholders, affected parties, and government agencies
- Coordinate additional provincial and external support to local authorities

Canadian Forces

- Operational and Logistical support under local IC

Coroners Services

- Body recovery and investigation

5 Conclusion

The purpose of this report was to compare the relative effectiveness of wireless communications that are currently available today against those same communications complemented by a public safety broadband component. To do so, a theoretical public safety emergency based on a significant wildland-urban interface fire in the lower interior of British Columbia was devised. The progression of the wildland-urban fire incident was captured over six key time periods along with the ensuing emergency response events associated with each period. This was then used to draw out the communications needs at each stage of the fire, and to compare the effectiveness of wireless capabilities with and without PSBN.

As illustrated in Sections 2 and 3 of this document, the presence of the PSBN has the potential to make a profound impact on the manner in which a variety of emergence response missions are carried out. The PSBN is an intelligent conduit that allows applications and services to be used that would otherwise not be possible on communications systems that have less capacity or become unavailable during emergencies when the systems become congested.

The greatest potential effect of the PSBN in this use-case is demonstrated by its ability to deliver broadband communications services to emergency responders intelligently, and in adverse conditions, where other systems that are based on similar technology would fail under those conditions. The PSBN enables the persistent use of applications and services that significantly enrich emergency responders' situational awareness, as well as other public safety users involved in the use-case, resulting in faster response times, fewer human casualties, less economic losses and quicker recovery of societal structures.

References

[1] Video from Precision Information on a vision of how broadband communications and information integration can be used in support of wildfire suppression and recovery. https://www.youtube.com/watch?v=5tfnmhl-A54 (Access date: 2 March 2017).

[2] Report on the cause of the deaths of 19 firefighters while battling the Yarnell Hill, AZ wildfire on June 30, 2013. Arizona State Forestry Division, "Serious Accident Investigation Report," 23 September 2013.

[3] NY Times article on the findings of the Yarnell Hill Serious Accident Investigation Report. http://www.nytimes.com/2013/09/29/us/report-cites-poor-communication-before-firefighters-deaths-in-june.html (Access date: 2 March 2017).

[4] BC Ministry of Forests and Range – Wildfire Management Branch, "Review of the 2009 Fire Season," March 2010.

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Annex A Vehicles and equipment

The following vehicles or personnel within the vehicles would either be equipped with or have access to LMR and PSBN communication devices, as required.

- 45 fire apparatus
- 32 bulldozers
- 17 excavators
- 14 skidders with water tanks
- 20 water tenders
- 11 lowbeds for transporting heavy equipment
- 147 vehicles for personnel transport (crews, single resources, etc.)
- 8 mobile medical treatment centres (private sector ambulances)
- 15 BC Ambulance Services ambulances
- 2 portable fire retardant pits with support vehicles (tanker, mixing crew)
- 24 helicopters complemented with support vehicles
- 75 military vehicles
- 23 police cars
- 12 SAR command and support vehicles
- Coroner vehicles
- 19 public works vehicles
- 30 utilities vehicles
- There is a steady stream of day visitors to fire camps and incident sites—i.e. trades, local suppliers, sewage pumpers, etc.

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Annex B Potential users, devices and types of data

Users and Devices

User, Device	Geographical Location
WMB attack crew and urban fire responders and ICP, hand-held terminal for graphics display, GPS tracking, tactical voice, data capture, gateway for tactical cameras and other operational information	En route and incident area
ICP, interactive video terminals, video conferencing, networked computers, weather station and other sensors, satellite terminal, interoperability gateway for communicating with other responders and support services; ground-to-air	Incident area
Police and SAR, Mobile data and hand-held terminals	En route and incident area
Ambulance; Mobile data and hand-held terminals, patient monitoring stations	Incident area and en route
EOCs, interactive video terminals, video conferencing, networked computers, strategic voice communications	Outside incident area
Utilities, Mobile data and hand-held terminals	En route and incident area and EOC

Type of Data

Data Source	Type
Vehicle and other asset location	Binary files, response to polling
Responder position location	Binary files, response to polling
Responder tactical voice	Audio streaming
Tactical camera feeds	Video steaming
Video Conferencing	Video and audio streaming
IP SMS, MMS messaging	File transfer on demand
EM vital signs monitoring	Binary files, response to polling
Communicate sitreps & mapping to Fire Centre Dispatch and other stakeholders	Binary files
Incident reporting and resource management system databases—remote access and exchange	Binary files and transfer on demand
Online GIS	Binary files and transfer on demand
High resolution imagery	Binary files

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List of symbols/abbreviations/acronyms/initialisms

CAF	Canadian Armed Forces
COM-L	Communications Leader
COM-T	Communications Technician
DRDC CSS	Defence Research and Development Canada – Centre for Security Science
DS	Deployable System
EOC	Emergency Operations Centre
F/P/T IWG	Federal/Province/Territorial Interoperability Working Group
IAC	Initial Attack Crew
IACL	Initial Attack Crew Leader
IC	Incident Commander
ICP	Incident Command Post
ICS	Incident Command System
ISED	Innovation, Science and Economic Development
MoFLNRO	Ministry of Forests, Lands & Natural Resource Operations
PECC	Provincial Emergency Coordination Centre
PFRC	Provincial Fire Reporting Centre
PREOC	Provincial Regional Emergency Operations Centre
ProSe	Proximity Services
PS	Public Safety Canada
QoS	Quality of Service
RFC	Regional Fire Centre
RMS	Records Management System
SA	Situational Awareness
SAR	Search and Rescue
SOW	System-on-wheels
WMB	Wildfire Management Branch
WPS	Wireless Priority Service

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Public safety broadband wireless communications is an emerging capability that will provide public safety users with broadband wireless connectivity in support of feature rich applications that will greatly enhance their communications and information sharing capabilities. There are many public safety broadband initiatives worldwide that are currently underway. In Canada, the public safety broadband initiative is known as the public safety broadband network (PSBN), which is essentially a cellular network much like commercial cellular networks, but built for public safety users.

Traditionally, first responders and public safety users use land mobile radio (LMR) with push-to-talk voice and an ability to send and receive data but only in a very limited manner. In some cases, users augment their radio communications with commercial cellular service, providing them access to broadband data services. This report compares the effectiveness of LMR complemented by commercial cellular service with a PSBN service in the context of a theoretical wildland-urban interface fire use-case.

Les communications sans fil à large bande de sécurité publique constituent une capacité émergeante qui fournira aux utilisateurs de sécurité publique une connectivité sans fil à large bande pour appuyer des applications riches en fonctionnalités qui amélioreront grandement leurs capacités de communications et de partage de l'information. De nombreuses initiatives de sécurité publique dans le monde entier sont actuellement en cours. Au Canada, l'initiative de sécurité publique à large bande est connue sous le terme de Réseau à large bande de sécurité publique (RLBSP) qui est essentiellement un réseau cellulaire semblable à des réseaux cellulaires commerciaux, mais créé pour des utilisateurs de sécurité publique.

Traditionnellement, les premiers intervenants et utilisateurs de sécurité publique utilisent la radio mobile terrestre (RMT) avec messagerie vocale instantanée à bouton d'émission (PTT) et capacité à transmettre et recevoir des données, mais seulement de manière très limitée. Dans certains cas, les utilisateurs accroissent leurs communications radio avec un service cellulaire commercial, leur permettant d'accéder aux services de transmission de données à large bande. Ce rapport compare l'efficacité de la RMT complétée par le service cellulaire commercial avec un service RLBSP dans le contexte d'un cas théorique d'application pour les feux dans les zones périurbaines de végétation.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g., Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Wireless; broadband; Long Term Evolution (LTE); Communications networks; public safety communications; 700 MHz; use case; emergency